Appl. No. 09/475,190
Amdt. Dated March 10, 2004
Reply to Office action of December 15, 2003
Attorney Docket No. P12414/040020-187
EUS/J/P/04-6050

Listing of Claims:

1. (Original) In a network including a first node and a second node, a method for regulating a frequency deviation of an oscillator in the first node comprising the steps of:

receiving a time stamp message at the second node from the first node;

transmitting a reply time stamp message from the second node to the first node, wherein the reply time stamp message includes a time of transmission of the reply time stamp message and the second node's estimation of a time interval; and

calculating an estimated frequency deviation of the oscillator in the first node using the second node's estimation of the time interval in the reply time stamp message.

A9

2. (Original) The method of claim 1, further comprising the step of:

adjusting the oscillator in the first node using the calculated estimated frequency deviation.

3. (Original) The method of claim 1, wherein the time interval is a time period between the transmission of two time stamp messages between the first and second nodes.

4. (Original) The method of claim 1, further comprising the steps of :

estimating, in the first node, an absolute time of the transmission of the time stamp message from the first node to the second node ; and

transmitting another time stamp message from the first node to the second node, wherein the another time stamp message includes the estimated absolute time of

transmission of the time stamp message and an uncertainty value as to the accuracy of the estimated absolute time of transmission of the time stamp message.

5. (Original) The method of claim 4, wherein the uncertainty value of the estimated absolute time is calculated using a Kalman observer.

6. (Original) The method of claim 4, further comprising the step of :

estimating a variance of a transmission delay of the network, wherein the uncertainty value of the estimated absolute time is increased by the variance of the estimated transmission delay.

A2 Cont.

7. (Original) The method of claim 4, further comprising the steps of :

estimating, in the second node, the absolute time of the transmission of the time stamp message from the first node to the second node ; and

determining, in the second node, whether to use the first node's estimation of the absolute time in the determination of the time deviation of the oscillator of the second node as a function of the first node's estimation of the absolute time, an uncertainty value of the first node's estimation of the absolute time, the second node's estimation of the absolute time and the uncertainty value of the second node's estimation the absolute time.

8. (Original) The method of claim 1, further comprising the steps of :

transmitting a plurality of time stamp messages from the first node to the second node ;

receiving a plurality of reply time stamp messages at the first node ; and

estimating a network delay and a variance of the network delay using a time of transmission of each of the plurality of time stamp messages and a time of reception of each of the plurality of time stamp messages.

9. (Original) The method of claim 8, wherein the estimated network delay and the variance of the estimation network delay are used to establish a confidence interval which indicates whether a time stamp message was stuck in the network.

10. (Original) The method of claim 1, wherein the reply time stamp message also includes an uncertainty value of the estimation of the time interval, and the uncertainty value is a factor in the step of calculating the estimated frequency deviation.

11. (Original) The method of claim 10, wherein the uncertainty value of the estimation of the time interval is calculated using a Kalman observer.

12. (Currently Amended). The method of claim 10, further comprising the step of:

estimating a variance of a transmission delay for the network, wherein the uncertainty value of the estimation of the time interval is increased by the ~~varaince~~ variance of the transmission delay.

Appl. No. 09/475,190
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EUS/J/P/04-6050

13. (Original) The method of claim 1, further comprising the steps of :

receiving another time stamp message at a third node ;

transmitting another reply time stamp message from the third node to the first node, wherein the another reply time stamp message includes a time of transmission of the another reply time stamp message and the third node's estimation of another time interval ; and

calculating the estimated frequency deviation of the oscillator in the first node using the second node's estimation of the time interval and the third nodes estimation of the another time interval.

14. (Original) The method of claim 13, wherein the time interval is a time period between the transmission of two time stamp messages between the first node and second node, and the another time interval is a time period between the transmission of two time stamp messages between the first node and the third node.

15. (Original) The method of claim 13, wherein the first node, the second node and the third node are one group in a grouped network, the method further comprising the step of :

exchanging time stamp messages between the first node and another node, the another node being part of another group in the grouped network.

16. (Original) The method of claim 13, wherein the first node is a time server in an Internet Protocol network.

17. (Original) The method of claim 1, wherein the first node or the second node is a radio base station.

18. (Original) The method of claim 1, wherein the time of transmission on a physical layer is included in the reply time stamp message.

19. (Original) The method of claim 1, wherein the time stamp message includes a first sub-message and a second sub-message, the first sub-message containing a sequence number and the second sub-message containing the sequence number and a time of transmission of the first sub-message.

20. (Currently Amended) A network comprising :

a node including :

an oscillator ;

means for receiving time stamp messages from another node within network ;

means for transmitting reply time stamp messages to said another node, the reply time stamp messages containing a time of transmission, a time elapsed since a previous time stamp message was transmitted, and an uncertainty value

as to the accuracy of the time elapsed since the previous time stamp message was transmitted; and

a Kalman observer for determining a frequency deviation of the oscillator using information in a received time stamp message.

21. (Cancelled)

A3 Cont.

22. (Currently Amended) The network of claim 22 ~~claim 21~~, wherein the node further comprises:

means for placing the time of transmission on a physical layer in the reply time stamp message.

23. (Original) The network of claim 22, wherein the means for placing the time of transmission in the reply time stamp message is a media access controller.

24. (Original) The network of claim 23, wherein the network is a ethernet network.

25. (Original) The network of claim 20, further comprising:

a second node ; and

a third node including an accurate time or frequency reference.

26. (Original) The network of claim 25, further comprising:

a switch between the third node and the first and second nodes, wherein time stamp messages are sent from the third node to the node and the second node.

27. (Original) The network of claim 26, wherein the network operates according to an ethernet protocol.

28. (Original) The network of claim 27, wherein time stamp messages which are delayed in the network more than a predetermined amount of time are discarded by a node receiving the delayed time stamp messages.

29. (Original) The network of claim 25, wherein the Kalman observer determines the frequency deviation of the oscillator using time stamp messages received from the third node and the Kalman observer determines an absolute time for the node using time stamp messages received from the second node.

30. (Original) The network of claim 29, wherein the node, the second node and the third node are a group in a grouped network, and wherein the second node contains a second oscillator and the third node contains a third oscillator, whereby a frequency drift of the oscillator in the node is--the same as a frequency drift of the second and third oscillators.

31. (Original) The network of claim 25, wherein the accurate time or frequency reference is a global positioning satellite (GPS) receiver.

32. (Original) The network of claim 25, further comprising :

a first switch between the third node and the node ;

a second switch between the second node and the third node ; and

a master switch between the third node and the first and second switches, wherein time stamp messages are sent from the third node to the first node and the second node and time stamp messages which are queued in the first, second or master switch are discarded by the node which receives the queued time stamp message.

33. (Original) The network of claim 32, wherein the third node is time server in an Internet Protocol network.

34. (Original) The network of claim 32, wherein the network operates according to an ethernet protocol.

35. (Original) The network of claim 32, wherein a node determines whether a time stamp message has been queued by determining a transmission delay of the time stamp message.

36. (Original) The network of claim 32, wherein time stamp messages have a maximum length, whereby the transmission delay between the nodes is minimized.

37. (Original) In a network, a method of regulating an oscillator in a node comprising the steps of :

transmitting a time stamp message from a first node to a second node, wherein the time stamp message includes the first node's estimate of a time interval ;

estimating, in the second node, the time interval ; and

adjusting a frequency of an oscillator in the second node using the first node's estimate of the time interval and the second node's estimate of the time interval.

38. (Original) The method of claim 37, further comprising the step of :

calculating an uncertainty value for the second node's estimate of the time interval,

wherein the time stamp message includes an uncertainty value of the first node's estimate of the time interval, and the frequency of the oscillator in the second node is adjusted using the uncertainty value for the first node's estimate and the uncertainty value of the second node's estimate in addition to the first and second nodes' estimate of the time interval.

39. (Original) The method of claim 38, further comprising the step of:

determining, in the first node, whether to use the second node's estimation of the first time interval in the determination of the frequency deviation of the oscillator of the first node as a function of the first node's estimation of the first time interval, the uncertainty value of the first node's estimation of the first time interval, the second

node's estimation of the first time interval and the uncertainty value of the second node's estimation of the first time interval.

40. (Original) The method of claim 39, further comprising the step of : triggering an alarm, in the first node, if it is determined that the second node's estimation of the first time interval is outside of a confidence interval.

41. (Original) The method of claim 37, further comprising the steps of:

transmitting a reply time stamp message from the second node to the first node, wherein the reply time stamp message includes the second node's estimate of the time interval and an uncertainty value as to the second node's estimate of the time interval ;

determining an uncertainty value for the first nodes estimate of the time interval ; and

adjusting the frequency of an oscillator in the first node using the first and second nodes' estimate of the time interval and the uncertainty values of the first and second nodes' estimate of the time interval.

42. (Original) The method of claim 37, further comprising the step of :

calculating an uncertainty value of the first node's estimate of the time interval and the second node's estimate of the time interval, wherein the estimates of the time interval and the uncertainty values of the nodes' estimate of the time interval is performed using a Kalman observer ; and

determining a frequency drift of the oscillator in the second node using a Kalman observer based on the first node's estimate of the time interval, the uncertainty value of the first node's estimate of the time interval, the second node's estimate of the time interval and the uncertainty value of the second node's estimate of the time interval, wherein the frequency of the oscillator in the second node is adjusted based on the determined frequency drift.

43. (Original) A network including a first node, a second node and a third node, a method for oscillator regulation comprising the steps of :

estimating, in the first node, the length of time of a first time interval and the length of time of a second time interval ;

receiving, in the first node, a time stamp message from the second node, wherein the time stamp message includes the second node's estimation of the first time interval ;

receiving, in the first node, a time stamp message from the third node, wherein the time stamp message includes the third node's estimation of the second time interval ; and

determining a frequency deviation of the oscillator of the first node based on the first node's estimation of the first and second time intervals, the second node's estimation of the first time interval and the third node's estimation of the second time interval.

44. (Original) The method of claim 43, further comprising the step of :

calculating, in the first node, an uncertainty value of the first node's estimation of the first time interval and an uncertainty value of the first node's estimation of the second time interval,

wherein the time stamp message from the second node also includes an uncertainty value of the second node's estimation of the first time interval,

wherein the time stamp message from the third node also includes an uncertainty value of the third node's estimation of the second time interval, and

wherein the step of determining the frequency deviation of the oscillator of the first node is also based on the first node's uncertainty value of the first node's estimation of the first and second time intervals, the second node's uncertainty value of the second node's estimation of the first time interval and the uncertainty value of the third node's estimation of the second time interval.

45. (Original) The method of claim 44, wherein the uncertainty values of the first node's estimation of the first and second time intervals are determined using a Kalman observer.

46. (Original) The method of claim 44, further comprising the step of:

determining, in the first node, whether to use the second node's estimation of the first time interval in the determination of the frequency deviation of the oscillator of the first node as a function of the first node's estimation of the first time interval, the uncertainty value of the first node's estimation of the first time interval, the second

node's estimation of the first time interval and the uncertainty value of the second node's estimation of the first time interval.

47. (Original) The method of claim 44, further comprising the step of :

sending an alarm, from the first node, to an operator of the second node if it is determined that the second node's estimate of the time interval with the uncertainty value of the second node's estimate of the time interval is more than a predetermined amount different from the first node's estimate of the time interval with the uncertainty value of the first node's estimate of the time interval.

48. (Original) The method of claim 47, wherein the first node includes a global positioning satellite (GPS) receiver.

49. (Original) The method of claim 46, wherein the first node includes a global positioning satellite (GPS) receiver, the method further comprising the steps of :

comparing the first node's estimate of the first time interval with the second node's estimate of the first time interval ; and

discarding, in the first node, the second node's estimate of the first time interval if the second node's estimate of the first time interval is more than a predetermined time longer or shorter than the first node's estimate of the first time interval and the uncertainty value of the second node's estimate of the first time interval is greater than the uncertainty value of the first node's estimate of the first time interval.

50. (Original) The method of claim 43, further comprising the step of :

estimating, in the second node, an absolute time of a predetermined event, wherein the time stamp message received in the first node includes the estimation of the absolute time of the predetermined event.

51. (Original) The method of claim 50, wherein the predetermined event is a beginning of transmission of the time stamp message sent from the second node to the first node.

52. (Original) The method of claim 50, further comprising the steps of :

determining an uncertainty value of the second node's estimation of the absolute time of the predetermined event ;

estimating, in the first node, the absolute time of the predetermined event ; and

determining an uncertainty value of the first node's estimation of the absolute time of the predetermined event, wherein the first node's estimation of the absolute time, the uncertainty value of me first node's estimation of the absolute time, the second node's estimation of the absolute time and the uncertainty value of the second node's estimation of the absolute time is used to update a time reference in the first node and a time reference in the second node.